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A Comparison Between Top-root Ratio Determinations by Oven-dry Weight and Volume Displacement

by

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Top-root ratios of our nursery stock, calculated on an oven-dried weight basis, have been determined for many years at most of our forest tree nurseries. Although considerable variation occurred among top-root ratios, acceptable ranges for various species have been published by Armson and Carman (1961). Thus in Ontario top-root ratios have been considered as one parameter in the morphological characterization of nursery stock.

In recent years top-root ratios have been largely ignored by some foresters because in their opinion the variability made its use meaningless. However we contend that more than just one parameter is required to characterize nursery stock.

Recently a volume displacement method has been used by some investigators in root growth capacity studies (Burdett 1979a, van den Driessche 1979) and also in determining the volume of other plant parts (Burdett 1979b). The method is fast, accurate and non-destructive, which allows the trees to be outplanted afterwards. Our purpose here is to make those nurserymen and tree planters who find top-root ratios a useful morphological parameter aware of the advantages of top-root ratio determination by volume displacement as compared to oven-dry weight. The results of a comparison between the determination of top-root ratios by the oven-dry weight method and by the volume displacement method are discussed in this note.

Materials and Methods

Four age classes of red pine (*Pinus resinosa* Ait.) nursery stock (3+0, 2+2, 2+1 and 1+2) were obtained in the spring of 1978 from Orono nursery and three age classes (3+0, 2+2 and 1+2) from Midhurst nursery. Four out of 44 bundles of 25 trees (for use in an outplanting comparison) were randomly selected from each age class and nursery for top-root ratio determination.

The top-root ratio by volume-displacement as described by Burdett (1979b) was determined first for each group of 100 trees. This involved immersing the root up to the root collar after which the stem portion was immersed up to the root collar. The immersion was done in a 4 litre beaker of water that stood on an electronic, 6-kg capacity, top-loader balance, which could be read to the nearest 0.1 g. The balance was tared after each reading. Care was taken that neither the roots nor the tops touched the sides of the beaker. The difference in balance reading in grams before and

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after immersion represented the volume of water in millilitres displaced by the immersed root or stem. This in turn is equivalent to their volume, since the density of water at room temperature is nearly 1. (Note: Since the balance was tared after each reading, i.e. set at zero, the weight in grams representing the volume is read directly.) Subsequently the roots were severed from the tops and placed in an oven at 65°C for 48 hours after which the roots and tops were weighed to the nearest 0.1 g.

The top-root ratios obtained by these two methods were subjected to linear regression analyses to ascertain the degree to which the two methods were correlated.

Results and Discussion

The top-root ratios determined by the volume displacement method are consistently higher than the oven-dry weight ratios (Figure 1). The variation

Figure 1 The average top-root ratios of nursery stock for several age-classes from Midhurst and Crono nurseries as determined by the volume displacement and oven-dry weight method. Each average is based on 100 trees and the 95% confidence limits reflects the variation of the mean.

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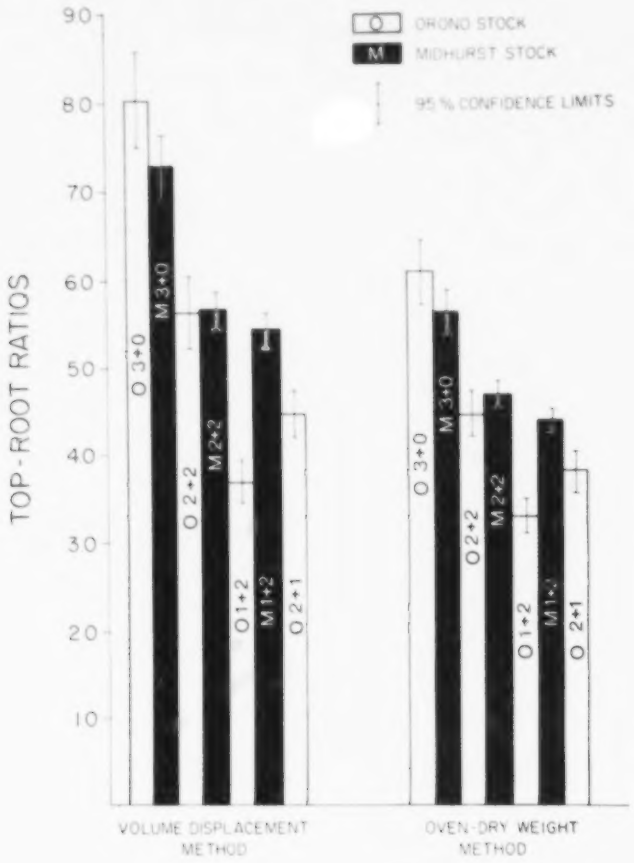

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TABLE 1 Linear regression equations between top-root ratios determined by the two methods and their correlation coefficients, for each age class and nursery

Nursery	Age class	Linear regression equation	99% Confidence limits at $\overline{XY}$	Correlation coefficient (r)
Orono	3+0	Y = 0.28 + 1.28X	±0.36	0.86
	2+2	Y =-0.58 + 1.39X	±0.22	0.91
	2+1	Y = 0.75 + 0.98X	±0.23	0.80
	1+2	Y = 0.32 + 1.02X	±0.15	0.87
Midhurst	3+0	Y = 1.29 + 1.07X	±0.30	0.79
	2+2	Y = 0.40 + 1.12X	±0.16	0.84
	1+2	Y = 0.13 + 1.21X	±0.15	0.81

X = Top-root ratio by oven-dry weight
Y = Top-root ratio by volume displacement

within the data appears to be similar for both methods as can be seen from the confidence limits. The reason for the consistently higher ratios with the volume displacement methods is due to differences in density between the tops and roots. The top contains far more intercellular spaces such as those between the mesophyll cells in the needles and between the cells in the pith, which are absent in the roots. Consequently with volumetric measurements the top will always have a higher volume relative to the root and therefore these top-root ratios will always be higher than those determined by oven-dry weight.

Good correlations clearly exist between the top-root ratios determined by the two methods (Table 1); furthermore the relationship is linear (Figure 2). Therefore the volume displacement ratios can be related back to oven-dry weight ratios by using the relationships presented in Table 1. This makes it possible to compare these ratios with those determined previously to see if any major shifts in top-root ratios are occurring. For example, it has been pointed out by Mullin (1977) that in Ontario over the last 20 years a major shift in top-root ratios occurred.

Top-root ratio determinations by volume displacement have some distinct advantages over such determinations by oven-dry weight:

1. It is non-destructive so that the trees can be outplanted afterwards.
2. The ratio can be determined in a matter of minutes. There is no 24 to 48 hour delay depending on what drying oven temperature is used.
3. The volume displacement ratios can be related to oven-dry weight ratios or vice versa if so desired.

Good top-loader balances, which can be tared, are now readily available, making it possible to read the volume of top and root directly and quickly. Furthermore many of the new balances have a terminal to which a print-out calculator can be connected and programmed to print out top-root ratios. Naturally, this type of balance can also be used for oven-dry weight determinations.

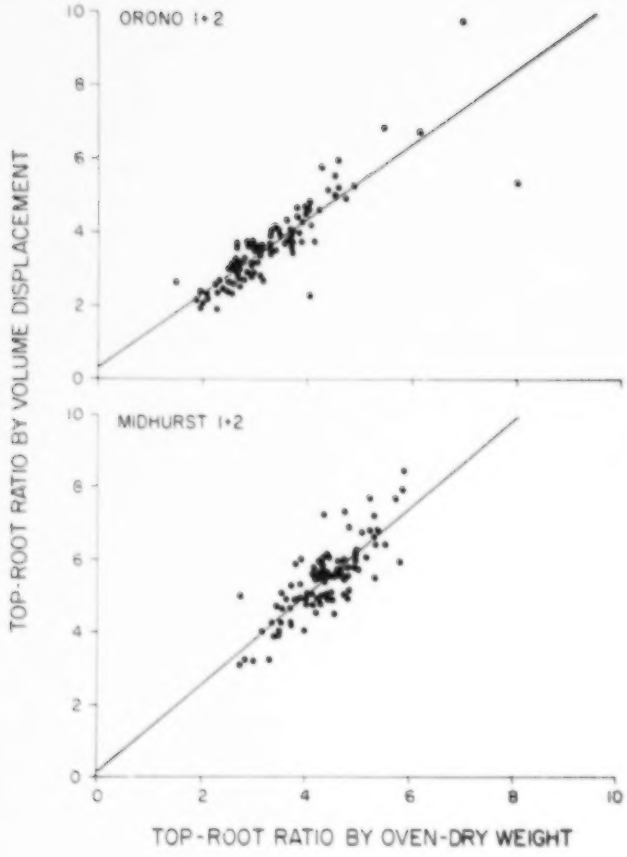

Figure 2 The correlation between the top-root ratio as determined by volume displacement and by oven-dry weight for the 1+2 age-class of Orono and Midhurst nurseries respectively. Each line is based on calculations from 100 observations.

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